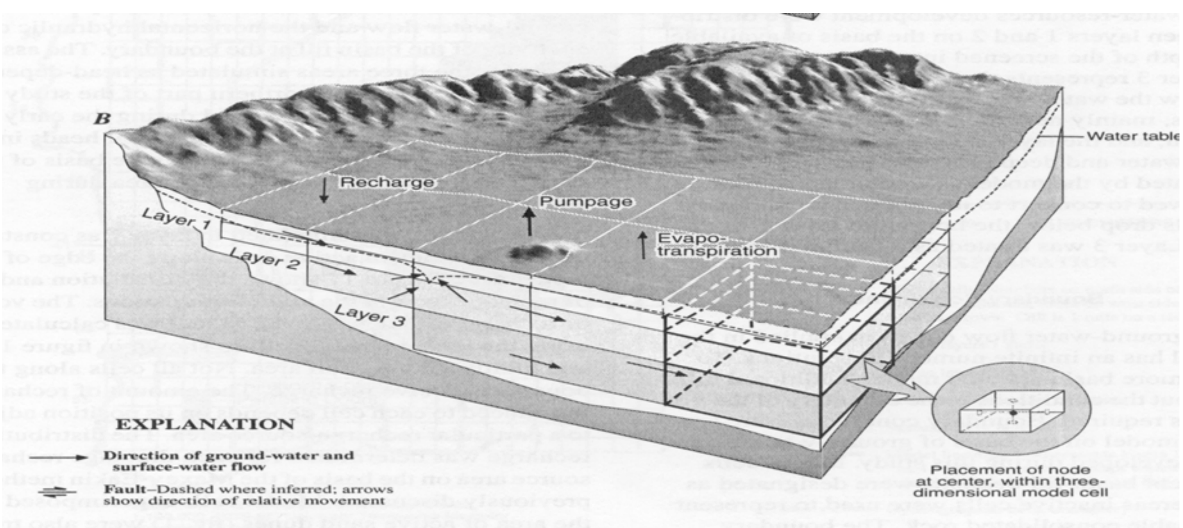
MANAGING GROUNDWATER IN THE CLARK FORK BASIN

Technical Conference Summary

University of Montana, Missoula
September 27, 2006



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Montana Department of Natural Resources and Conservation
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Clark Fork River Basin Task Force

CONTENTS

INTRODUCTION

The Clark Fork Task Force was statutorily created to develop and implement a water management plan for the Clark Fork River basin in Montana. Such a plan must consider groundwater, which is increasingly important as a source for new water uses in the basin. In its deliberations, the task force recognized that more information is needed about the basin's groundwater, recharge rates, and groundwater-surface water interrelationships.

The task force and other conference sponsors organized a Groundwater Technical Conference September 27, 2006, at the University of Montana, Missoula, to address the following goals:

- Review what is known about groundwater in the Clark Fork basin.
- Learn about groundwater modeling—what it is, how it is done, what data are needed, and what kind of questions modeling can address.
- Learn about other methods for assessing the impacts of groundwater use on surface and groundwater supplies.
- Examine groundwater case studies.
- Determine information and resource needs for more effective management of groundwater in the basin.

This report summarizes the presentations and discussions that took place at the conference.

The Complexities of Managing Basin Groundwater

Watersheds are highly complex and dynamic systems. They are comprised of a variety of interactive natural and human components, and are shaped and influenced by both natural and social forces. Watersheds are never static—they change over time, in response to short-term water uses and weather, and over the longer term in response to climatic trends, cumulative changes in water and land use, and geologic forces.

Our scientific understanding of watersheds has improved and expanded greatly over the last 200 years, but many of our tools and methods are relatively young. For some places and parameters, scarce data are available. In turn, even for well-studied parameters, demand for ever more credible, defensible management decisions leaves us always thirsting for more data. In short, what we want to know still outweighs what we do know.

Because of these complexities, we may never fully understand or perfectly characterize a system as large and varied as the Clark Fork basin. Indeed, some components—such as precipitation or tributary underflow—are out of our control. Other components are more susceptible to being managed. For example, we can measure and regulate consumptive uses, such as irrigation and domestic use, and some aspects of groundwater recharge, such as canal leakage and return flows.

Challenges of Unitary Management

Managing surface and groundwater as a connected, interactive resource (known as unitary or conjunctive management) brings additional challenges:

- Impacts cause changes in the energy of water moving through the system.
- Impacts ***do not*** equate to injury on another user.
- Impacts on surface supplies are visible, and people are familiar with them. But impacts on groundwater supplies are invisible, and many people are less familiar with or even unaware of groundwater conditions.
- Impacts typically take a long time to propagate through an aquifer.
- Impacts can propagate both 'upstream' and 'downstream.'
- Impacts are often greatly attenuated.
- Senior groundwater impacts arrive earlier than junior (the reverse of surface water impacts).
- Wide scale curtailment will probably trigger a review for 'futile call.'
- Injuries are seasonal, but impacts are year-round.
- It is difficult to isolate impacts from pumping from impacts from other sources (such as conversion to sprinkler irrigation, drought, etc.).

Socio-Political Considerations

As the above list illustrates, science is only part of the equation. Social and political considerations also weigh on the management of the basin's surface and groundwater resources. Demands on the basin's water are changing, reflecting a growing population, increasing residential and commercial development, and greater reliance on groundwater supplies. These trends lead to new forms of competition and conflict over water, and the various water users are strongly at odds—they seem to "want to be polarized." To make matters worse, opinions are often swayed by misinformation and an incomplete understanding of the data, basin hydrology, and water law. (The ongoing work in the Clark

Fork basin—including this report—can help address these challenges before they become actual problems.)

These challenges can be addressed within the scope of the Clark Fork River Basin water management plan. Any specific solutions should (1) stay within the bounds of the prior appropriation doctrine (with some minor modifications), (2) aim to keep as many water users in business as possible, and (3) consider a full range of issues, such as aquatic species and habitat, municipal growth, the impacts of development, and water quality.

GROUNDWATER IN THE CLARK FORK BASIN

Table 1 summarizes the apparent water budget of the Clark Fork basin in broad-brush (annual average) numbers.

Table 1. A Water Balance?

	Million Acre-feet	Sources
Precipitation	22.06	1971-2004 average based on Western Climate Division data.
Discharge	13.74	1971-2004 average annual discharge near Plains.
Irrigation	0.28	MT DNRC water rights listings for irrigation use, Sept. 2006.
Municipal	0.21	MT DNRC water rights listings for municipal use, Sept. 2006.
Domestic	0.08	~ 52,000 wells @ 1.5 af consumptive use each.
Evaporation/Evapotranspiration	7.75	By difference.

The Clark Fork basin consists of mountain and valley topography. It valleys are block fault valleys that have been filled, scoured, refilled, and shaped by geologic forces. These intermontane valley bottoms support most of the basin's development, and most wells are finished and pulling water from the alluvial valley fill. The hydrogeology of the Clark Fork basin varies among its sub-basins. The Bitterroot, Deer Lodge, Drummond, and Missoula valleys are filled with relatively shallow sand and gravel debris from the valley margins. In contrast, the Kalispell Valley and parts of the Mission Valley feature a deep alluvial deposit, which is the primary aquifer throughout the valley. In most canyon settings, wells tap into very shallow near-stream alluvium or fractured bedrock near the valley margins. Climate and water use also vary across the basin.

Groundwater development is significant within the basin. Logs for more than 60,000 water wells are recorded in the Ground-Water Information Center (GWIC) at the Montana Bureau of Mines and Geology. About 20,700 of those wells have been drilled since 1995, at a fairly even rate of about 1,800 wells per year. The state legislature has closed the Upper Clark Fork and Bitterroot basins to new groundwater development. GWIC maps of well density show where development has occurred. In each sub-basin, between 82 and 89 percent of the wells are for domestic use, but irrigation is the largest consumptive use by volume in the basin as a whole.

New subdivision development is driving most of the new groundwater appropriations. In fiscal year 2006, growth added more than 5,000 lots to the basin. Understanding the impacts from one large subdivision can be difficult, but coming to terms with the cumulative impacts from growth throughout the basin is even more challenging. Groundwater managers are often unclear about what level of analysis is appropriate. Should numeric modeling and analysis be limited to localized impacts? Alternatively, since change and impacts propagate slowly and are attenuated over time, should they be analyzed on a sub -basin or watershed scale? The cumulative impacts over time may begin to show long after initial development and are likely to not be noted during a single season of water demand. (Are EAs adequate, or should an EIS or a basin-wide programmatic EIS be developed?) Given the small size of some development proposals but the potential overall impact of development throughout the basin. In addition, subdivisions bring their own set of emerging problems that are less well understood, such as the effects of increasing impervious surfaces, storm drainage issues, and pharmaceuticals entering the water.

GROUNDWATER QUALITY CONCERNS IN THE CLARK FORK BASIN

Over the last two decades, Montana water policy has periodically evaluated groundwater protection. Several tools have been developed to protect the groundwater resource. Those tools--including changes in statute--address waste disposal, water protection, and monitoring. Some, such as water quality districts, are uniquely local developments that aid in local monitoring and regulation. Our current and past activities place the groundwater resource at risk. There are considerable concerns, some of them scientifically well grounded, related to the current changes in land use related to non-urban growth. Both waste disposal and drinking water quality are issues of concern. Groundwater supplies in the basin are at risk from a number of contaminants, in particular the following:

Nitrate

- EPA drinking water standard is 10 mg/L as N.
- Nitrate sources include septic tanks, animal waste (feedlots, pasture runoff), organic or chemical fertilizer, mining (blasting residue, cyanide).
- Cost of analysis: very low to moderate (test strips are inexpensive; IC, colorimetry are less than $20).

Heavy Metals and Metalloids

- Heavy metals (cadmium, copper, mercury, lead, zinc) occur mainly as isolated problems near mining centers.
- Metalloids (selenium and arsenic) occur from mining, naturally elevated geologic levels, and geothermal sources.
- New EPA drinking water standard for arsenic is 10 μg/L (ppb). A fair number of private wells in the basin exceed this value. Exposure raises the risk of certain cancers and can be toxic at higher levels.
- Cost of analysis: moderate to high.

Radon

- This colorless, odorless, radioactive gas is moderately soluble in groundwater.

- Radon leaches into water from uranium-rich sediment or bedrock, especially granite.
- People ingest radon in drinking water or inhale it during shower, laundry, etc. Exposure raises the risk of certain forms of cancer.
- Cost of analysis: moderate.

Pesticides and Pharmaceuticals

- Pesticides (including herbicides) mostly come from agricultural use.
- Pharmaceuticals enter water supplies from human uses (your medicine cabinet) and livestock (hormones, antibiotics).
- Cost of analysis: rapid screening is relatively cheap, but testing for individual compounds is expensive!
- This is an emerging problem; very little is known.

Pathogens

- Protists (e.g., giardia); most are larger than 100 mm.
- Bacteria (e.g., E. coli); range in size from 0.5 mm to 10 mm.
- Viruses (e.g., rabies, HIV) range in size from 0.01 mm to 0.3 mm.

Future land use changes would also affect water quality in the basin. Shifting from flood to sprinkler irrigation could reduce "flushing" of shallow groundwater, leading to an increase in salinity and a possible increase in contaminant levels. Similarly, continued subdivision development could lower local water tables and increase concentrations of nitrate, pathogens, and pharmaceuticals.

To date, mining impacts have been mainly confined to Butte and Anaconda, as well as the upper Clark Fork riparian corridor. Smaller historic mining districts in other sub-basins within the Upper Clark Fork drainage are also undergoing restoration activities or investigations.

Ongoing reclamation along the Upper Clark Fork main stem is reducing heavy metal loads, and removal of Milltown Dam and associated sediments should reduce the arsenic-rich groundwater plume that has contaminated area wells. Upstream, lime treatment of water from the Berkeley Pit is scheduled to continue at least into 2015. The questions remains whether the upstream restoration and bypassing of the Warm Springs pond will be successful. It is possible that increased sulfate and total dissolved solids could redevelop in the Clark Fork system with these changes in management.

Also, new proposals for mining development in the basin continue to be raised. New mining projects have been proposed for both the Blackfoot River and Rock Creek near Clinton.

TOOLS FOR STUDYING SURFACE/GROUNDWATER INTERACTION

A number of tools and techniques are needed to build an understanding of the interaction of surface and groundwater resources. The main parameters measured are groundwater levels (or elevations), seepage, streamflow, water temperature, and chemistry. Case studies presented at the conference demonstrated how an array of methods could be used to develop multiple "lines of evidence" that, taken together, reveal surface/groundwater interactions. The conference focused on two methods in particular—temperature tracing and modeling.

Temperature Tracing

Researchers with the U.S. Geological Survey have found that tracing temperature is an economical and robust way to study the interaction of surface and groundwater. To measure and monitor differences in temperature, scientists use continuous recorders, longitudinal surveys, thermal imagery (aerial infrared photography), and fiber optics. Tracing temperature reveals areas of groundwater recharge, gaining and losing stream reaches, and travel time from surface to wells at specific depths and distances within the aquifer. Reliable temperature and groundwater transport models are readily available.

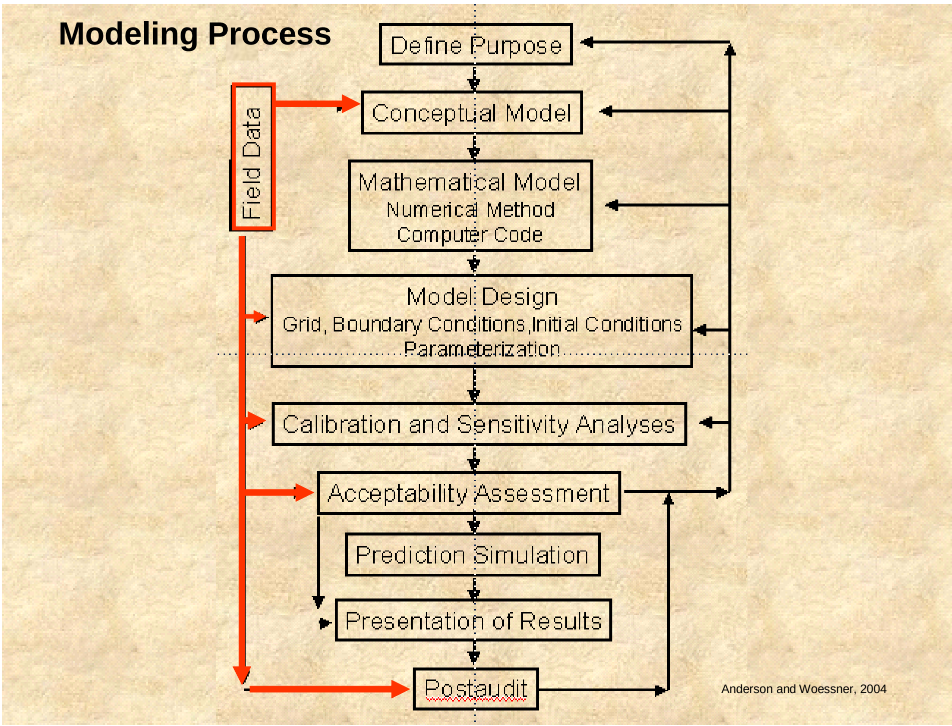
Tracing metals or chemicals in the water tends to raise concerns (real and perceived) when the results are publicly reported. Temperature is largely free of such stigma.

Modeling

A model is a simplification of a real-world system. Its purpose is to function as a representation of the natural system, just as road maps are models of the real roads and towns on the earth's surface. As a tool, groundwater models aid in interpretation of data or aid in predicting change.

Groundwater models may be conceptual, scale, analog, or mathematical (analytical and numerical). Such models are not of the same scale, nor do they serve the same purpose. As models become more complex they require more data. Mathematical models are common analytical tools used on a very localized scale to predict impacts of pumping and draw down. With the advent of computerized geographic information systems, there has been a marked increase in the development of numeric conceptual models.

A computerized numerical model of an aquifer slices the earth into layers and discrete blocks or *cells* of space and intervals of time. Researchers then assign data on evapotranspiration, well-pumping, streamflow, aquifer recharge, and other factors into each cell in this 3-D cross section. Equations link the data from one cell to another, and researchers define the boundaries of the model and initial conditions. The model can then be run and tested for accuracy against real-world measurements. The flow chart below outlines the basic steps of the modeling process.



Modeling versus Management

Modeling is increasingly used to predict future conditions and "what if" scenarios—an attempt to understand how groundwater supplies will be affected given certain changes in use or management. Such models contain inherent uncertainty, but they are the only tools we have to assess complex systems. This uncertainty must be acknowledged (and explained to decision makers and stakeholders). To provide a reasonable basis for making scientifically supportable decisions, modelers should avoid relying on only one model and finite results. Decision makers are far better served when we use multiple conceptual models and present ranges of likely results.

Unfortunately, common modeling practice is often at odds with groundwater management needs. Models tend to be "over tuned"—becoming less useful as they gain precision because they lose accuracy. (The more precise a model is, the less accurate it tends to be in depicting the dynamic real-world system). As demand for precision rises, groundwater models become an end unto themselves.

Managers need models, but models can create as many headaches as answers and often provide openings for lawyers to argue over results.

In the United States, active groundwater management developed mainly in response to court decisions or the threat of a suit. Early management attempts frequently began with enabling legislation, typically limited to allocating water. Following legislation, management has often been limited further by courts. As competition for groundwater increases, courts become more decisive, and decisions in federal courts begin to dominate. Conflicts over water increase as competition for all resources increases, and this leads to even more court involvement. State courts tend to try to maintain the status quo. Federal courts become the venue to break the status quo.

In some cases (e.g., California's San Gabriel basin and the Edwards Aquifer in Texas), municipalities and states lost control over groundwater decisions because they allowed a management vacuum to form. Even when aquifer systems were fully contained within one state, federal courts and agencies drove management choices. The Clark Fork basin spans several states, and interstate water fights always end up in federal courts. Montanans need to anticipate how we will respond to increased competition for water. Are existing regulatory structures adequate? Do we have sufficient data and modeling evidence to support our claims and concerns about competing demands? Do we have adequate funding for legal battles? In short, have we been proactive in effectively managing our surface/groundwater resources?

GROUNDWATER MANAGEMENT NEEDS

Data Needs

Water well locations –Well drillers need training and systematic methods for accurately reporting water well locations. Hand-written log reports often contain errors and are hard to read. Well owners may live out of state, so confirming information can be difficult, costly, and time consuming. Relying on GPS data doesn't eliminate problems. Latitude readings may be recorded incorrectly (misplaced degree, minute, and decimal symbols), and drillers who use GPS tend to not record a lot-block address, township-range-section location, or other information that corroborates the well location.

Aquifer test reports – Transmissivity, hydraulic conductivity, and storativity are likely to become more important as managers, water users, and others attempt to model groundwater systems. GWIC is currently developing time-drawdown plots to help users determine the usefulness of data and results from aquifer tests. In addition, Montana needs to capture aquifer test data in the same manner that it acquires water-well log data. This should be statutorily required. (GWIC has 22 aquifer tests within the basin reported in its database, but no one knows how many tests have actually been conducted.)

Water quality monitoring – While data for some contaminants are available, others are not adequately monitored to ensure human health and safety. Given the lag time before contaminants show up in groundwater tests (often decades after they were introduced to the water system), future problems will likely include a higher prevalence of arsenic, pesticides and herbicides, organic compounds, and pharmaceuticals in our groundwater. We need more widespread and comprehensive monitoring for these and other contaminants, and we need a better understanding of their effects on human and environmental health.

Sub-basin water modeling – Should the state or local governments begin the development of sub-basin models? With the work completed by MBMG that includes updated geologic mapping, well inventory, groundwater data collection, and development of a long-term well monitoring network, considerable information is available, at least in areas of growth. As part of the state's TMDL planning process, the Montana Department of Environmental Quality is in many basins developing Geographic Information System (GIS) based models.

Should we investigate those frameworks to determine if they can be expanded to serve as a base to build watershed groundwater models?

Infrastructure Needs

Water level monitoring – Impacts from new water development projects will more and more be defined though numerical modeling. Model results must be calibrated to long-term water-level records. The statewide monitoring network in heavily populated areas must be enhanced. Dedicated monitoring wells must eventually replace "wells of opportunity" in sub-networks such as in the Bitterroot. We need more monitoring wells. Additional recorders should be installed to provide the amount and quality of information needed to support models. GWAA at MBMG needs a FTE to manage the network to insure that we obtain the best data possible.

Unresolved Issues and Questions

- What is our management goal? What do we want to manage, and to what end? (For example, do we want to manage to sustain existing streamflows, or natural (pre-development) streamflows? Should we continue to manage water-use changes on a case-by-case basis, or develop a basin-wide water banking system?)
- How should hydraulic connection be evaluated for permitting?
- What tools should the permitting agency use to assess stream depletion and to design augmentation plans?
- Can augmentation plans be monitored or otherwise verified? How?
- Should basin-wide numerical models be used for making groundwater management decisions?
- What novel augmentation approaches can we anticipate?
- What do we mean by "sustainability" in terms of development and groundwater appropriations? What are our criteria for making permitting decisions?
- How can we better coordinate water management among and within the various local, state, federal, and tribal agencies in Montana?
- How should we proactively coordinate water allocation among the states in the Columbia River basin?
- We must improve our ability to gather and use data. How can we most effectively present our information and funding needs to the state legislature and public research institutions?